

1 CLAIMS

2

3 1) A frequency stabilisation apparatus for stabilising a
4 frequency output of a laser cavity, the frequency
5 stabilisation apparatus comprising an intracavity
6 birefringent etalon, wherein the intracavity
7 birefringent etalon is employed to derive a polarised
8 electric field component from an intracavity electric
9 field of the laser cavity, the orientation of
10 polarisation of the polarised electric field
11 component being dependent on the frequency and
12 polarisation of the intracavity electric field.

13

14 2) A frequency stabilisation apparatus as claimed in
15 Claim 1 wherein the intracavity birefringent etalon
16 acts as a first quarter waveplate on the polarised
17 electric field component such that when the frequency
18 of the intracavity electric field corresponds to a
19 resonant frequency of the birefringent etalon the
20 polarised electric field component is linearly
21 polarised.

22

23 3) A frequency stabilisation apparatus as claimed in
24 Claim 1 or Claim 2 wherein the frequency
25 stabilisation apparatus further comprises a second
26 quarter waveplate.

27

28 4) A frequency stabilisation apparatus as claimed in
29 Claim 3 wherein the frequency stabilisation apparatus
30 further comprises an elliptical polarisation analyser
31 for analysing the state of polarisation of the
32 polarised electric field component on being
33 transmitted through the second quarter waveplate.

1

2 5) A frequency stabilisation apparatus as claimed in
3 Claim 4 or Claim 5 wherein an optical axis of the
4 second quarter waveplate is aligned with an optical
5 axis of the birefringent etalon such that on being
6 transmitted through the second quarter waveplate the
7 polarised electric field component is linearly
8 polarised, the plane of linear polarisation being
9 dependent on the frequency of the intracavity
10 electric field relative to the resonant frequency of
11 the birefringent etalon.

12

13 6) A frequency stabilisation apparatus as claimed in
14 Claim 4 or Claim 5 wherein an optical axis of the
15 second quarter waveplate is aligned at 45° relative
16 to an optical axis of the birefringent etalon such
17 that on being transmitted through the second quarter
18 waveplate the polarised electric field component of
19 an off resonance frequency is linearly polarised, the
20 plane of linear polarisation being dependent on the
21 frequency of the intracavity electric field relative
22 to the resonant frequency of the birefringent etalon.

23

24 7) A frequency stabilisation apparatus as claimed in any
25 of Claims 4 to 6 wherein the elliptical polarisation
26 analyser comprises a polarisation dependent
27 beamsplitter and two light detecting means wherein
28 the polarisation dependent beamsplitter is orientated
29 so as to resolve the polarised electric field
30 component into two spatially separated components
31 each of which is incident on one of the light
32 detecting means.

33

1 8) A frequency stabilisation apparatus as claimed in
2 Claim 7 wherein the elliptical polarisation analyser
3 further comprises an electronic circuit wherein the
4 electronic circuit derives an error signal from
5 electrical output signals generated by the two light
6 detecting means.

7

8 9) A frequency stabilisation apparatus as claimed in
9 Claim 8 wherein the electronic circuit further
10 comprises a feedback circuit for generating a
11 feedback signal in response to the error signal so as
12 to control the orientation of the birefringent etalon
13 within the intracavity electric field in order to
14 minimise the magnitude of the error signal.

15

16 10) A frequency scanning apparatus for scanning a
17 frequency output of a laser cavity comprising a
18 frequency stabilising apparatus as claimed in any of
19 Claims 1 to 9 and a cavity length adjuster that
20 provides a means for scanning a length of the laser
21 cavity.

22

23 11) A frequency scanning apparatus as claimed in Claim 10
24 wherein the cavity length adjuster comprises at least
25 one laser cavity mirror mounted on a piezoelectric
26 crystal.

27

28 12) A method for stabilising a frequency output of a
29 laser cavity comprising the steps of:

30 1) Employing a birefringent etalon to sample an
31 intracavity electric field of the laser cavity so
32 as to derive a polarised electric field component
33 whose polarisation is dependent on the polarisation

1 and frequency of the intracavity electric field
2 relative to a resonant frequency of the
3 birefringent etalon;

4 2) Deriving an error signal from the polarised field
5 component; and

6 3) Stabilising the birefringent etalon to the derived
7 error signal.

8

9 13) A method as claimed in Claim 12 wherein the polarised
10 electric field component is linearly polarised when
11 the intracavity electric field corresponds to a
12 resonant frequency of the birefringent etalon.

13

14 14) A method as claimed in Claim 12 or Claim 13 wherein
15 the polarised electric field component is
16 elliptically polarised when the intracavity electric
17 field corresponds to a non-resonant frequency of the
18 birefringent etalon.

19

20 15) A method as claimed in Claim 14 wherein the helicity
21 of the polarised electric field component is of an
22 alternative sign when the intracavity electric field
23 frequency is above or below the resonant frequency of
24 the birefringent etalon.

25

26 16) A method as claimed in any of Claims 12 to 15 wherein
27 the step of deriving the error signal comprises the
28 steps of:

29 1) Introducing a $\pi/2$ phase shift to the orthogonal
30 constituent components of the polarised electric
31 field component;

32 2) Resolving the orthogonal constituent components of
33 the polarised electric field component; and

1 3) Calculating an intensity ratio signal the
2 orthogonal constituent components of the polarised
3 electric field component.

4

5 17) A method as claimed in Claim 16 wherein the step of
6 introducing the $\pi/2$ phase shift to the orthogonal
7 constituent components of the polarised electric
8 field component results in the plane of polarisation
9 of the polarised electric field component being
10 directly dependent on the frequency of the
11 intracavity electric field relative to the resonant
12 frequency of the birefringent etalon.

13

14 18) A method as claimed in any of claims 12 to 17 wherein
15 the birefringent etalon is stabilised to the derived
16 error signal by controlling the orientation of the
17 birefringent etalon within the intracavity electric
18 field in order to minimise the magnitude of the error
19 signal.

20

21 19) A method for scanning a frequency output of a laser
22 cavity comprising:
23 1) Stabilising the frequency output of the laser
24 cavity in accordance with the method of any of
25 Claims 12 to 18;
26 2) Scanning an optical length of the laser cavity; and
27 3) Scanning the orientation of the birefringent etalon
28 within the intracavity electric field in order to
29 track the scanned optical length of the laser
30 cavity.